ACUTE EFFECTS OF VIBRATION ON THE RAT-TAIL ARTERY

Sandya Govindaraju, Brian Curry, James Bain, Danny Riley
Department of Cell Biology, Neurobiology and Anatomy
Medical College of Wisconsin, Milwaukee, Wisconsin, U.S.A.

Introduction

Acute vibration causes vasoconstriction in naïve human subjects[1]. Vibration-induced decrease in skin perfusion has also been reported in the rat-tail vibration model [2]. After vibration exposure, rat-tail arteries demonstrate vacuoles in smooth muscle cells, similar to that caused by pharmacological vasoconstrictors[3]. This study addressed the effects of different frequencies, durations and patterns of vibration on lumen size and vacuole formation using the rat-tail vibration model in male Sprague-Dawley rats (~300 g).

Methods

The different groups were: 4-hr continuous vibration at 30, 60, 120 and 800 Hz; continuous exposure durations of 5 min, 1 hr and 4 hr at 60 Hz; and 4-hr cumulative exposure of 60 Hz delivered intermittently in cycles of 10 min on and 5 min off. Acceleration was set at 49 m/s^2 r.m.s. for all frequencies. Unanesthetized rats were restrained in cages on a nonvibrating platform with their tails placed on a vibrating stage driven by a B&K motor (4809). The sham control animals were also placed in the vibration apparatus but not vibrated. Room temperature was controlled at 25 ± 1°C. Ventral arteries from proximal tail segments 7 were immersion fixed in aldehydes, embedded in epon-araldite and sectioned (0.5 µm) for morphological analysis. Vascular lumen sizes were measured as the percent ratio of the lumen perimeter to internal elastic membrane length using Image J software (NIH). The number of vacuoles in the smooth muscle layer of each artery section was counted.

Results

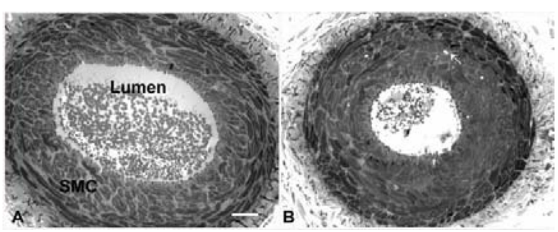

Fig 1: Semithin sections of arteries. A. Sham control. B. 4-hr vibration 60 Hz. In vibrated arteries, the lumen decreases in size, and smooth muscle cells (SMC) exhibit vacuoles (arrow). Bar equals 40 µm for each panel.

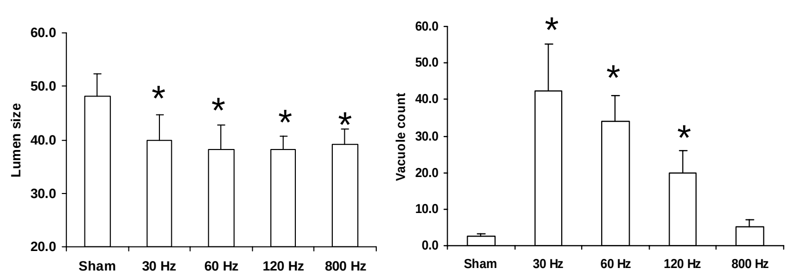

Fig 2: Bar graphs of lumen size and vacuole count when vibrated for 4 hrs at 30, 60, 120 and 800 Hz. * significantly different from sham, $p<0.05$.

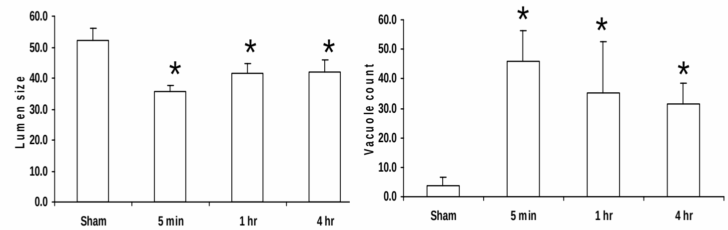

Fig 3: Bar graphs of lumen size and vacuole count when vibrated for 5 min, 1 hr and 4 hrs at 60 Hz. * significantly different from sham, $p<0.05$.

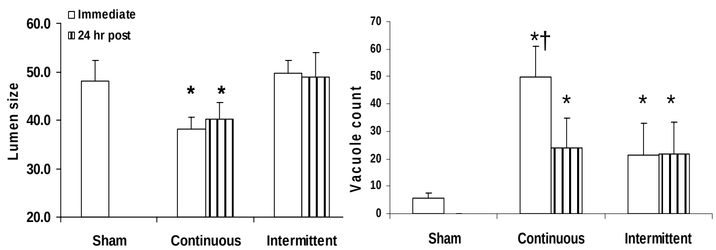

Fig 4: Bar graphs of lumen size and vacuole count when vibrated continuously or intermittently for 4 hrs at 60 Hz and examined immediately or 24 hr after exposure. * significantly different from sham, † significantly different from other vibrated groups, $p<0.05$.

Discussion

1. Vasoconstriction is induced by vibration at 30, 60, 120 and 800 Hz.
2. Vibration exposure of 60 Hz for 5 min is sufficient to cause vasoconstriction and generate smooth muscle cell vacuoles.
3. The decrease in lumen size persists at least 24 hrs after cessation of 60 Hz continuous vibration.
4. Both patterns of vibration, continuous and intermittent, cause the formation of smooth muscle cell vacuoles.

References

1. Bovenzi M, Griffin MJ, Ruffell CM. Vascular responses to acute vibration in the fingers of normal subjects. Cent Eur J Public Health 1995; 3 Suppl:15-18.

2. Curry BD, Bain JL, Yan JG, Zhang LL, Yamaguchi M, Matloub HS, et al. Vibration injury damages arterial endothelial cells. Muscle Nerve 2002; 25:527-534.

3. Curry BD, Govindaraju SR, Bain JL, Zhang LL, Yan JG, Matloub HS, et al. Nifedipine pretreatment reduces vibration-induced vascular damage. Muscle Nerve 2005; 32:639-646.

Supported by the Medical College of Wisconsin and in part by NIOSH grant R01 OH003493